Evaluation of the Windows Pesticide Screening Tool (Win-PST) for use in Hawaii

Context

The NRCS Pest Management Policy adopted in November, 2001 (Title 190, General Manual Part 404) requires that Pest Management Plans meeting Conservation Practice Standard 595: "Pest management" be developed where appropriate as part of RMS-level Conservation Planning. Conservation Practice Standard 595 (eFOTG Section IV: http://efotg.nrcs.usda.gov) states that: "Pest management environmental risks … must be evaluated for all identified water resource concerns. [State Standards shall include approved evaluation procedures such as NRCS' Windows Pesticide Screening Tool (WIN-PST) and National Agricultural Pesticide Risk Analysis (NAPRA).]"

At the present time, the State of Hawaii Department of Agriculture (HDOA) uses a locally developed system called the Comprehensive Leaching Risk Assessment System (CLERS) to estimate pesticide leaching risk. This system is based on the Revised Attenuation Factor (AFR) model developed by scientists at the University of Hawaii to simulate Hawaii conditions.

For Hawaii to comply with the NRCS Pest Management Policy, either Hawaii NRCS must adopt Win-PST as part of the state Conservation Practice Standard 595 or must obtain national approval to use an alternative risk assessment tool. Concern was expressed by NRCS-Hawaii technical staff that Win-PST, although extensively validated on the US mainland, might not provide accurate results under Hawaii soil and climate conditions.

Objective

The objective of this study was to evaluate the Win-PST model under Hawaii conditions and provide a recommendation to the NRCS-Hawaii state technical staff regarding its adoption as part of Conservation Practice Standard 595.

Evaluation components

Win-PST was evaluated and compared with CLERS on four major areas: scope, consistency, accuracy and support. Details of the components and criteria used are provide below:

Scope

- How much soil and chemical data are available?
- Can the user change soil or chemical input data to reflect new information?
- What are the results provided?

Consistency

- Are Win-PST leaching risk predictions consistent with CLERS predictions?

Accuracy

- Are Win-PST and CLERS predictions consistent with existing data?
  - Drinking water well well monitoring (USGS – NAWQA Program)
  - Field experiments

Support

- What types of support are available for the system?
  - How is soil and chemical information updated?
  - Will new versions of the system likely be developed as new information becomes available to improve the underlying model(s)?

Background of the risk assessment systems

This section provides a short introduction to the major features of both the Win-PST and CLERS systems. Published information concerning the details of both the Win-PST and CLERS systems is available elsewhere.

Win-PST

The Win-PST system was developed through the cooperative efforts of USDA-SCS, USDA-ARS and the Cooperative Extension Service (Goss and Wauchope, 1990). The Win-PST system is based on a mathematical model of the impact of both soil and pesticide properties on leaching risk. Model parameters were identified using a stepwise regression procedure relating a range of combinations of soil and chemical properties to the results of over 40,000 runs of the GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) model (for model details, see Leonard et. al. 1987). Win-PST provides estimates of pesticide pollution risk through leaching, surface water runoff and surface soil runoff. Win-PST was developed and has been validated primarily in the temperate regions of the continental US.

CLERS

The CLERS system is a computer-based decision support system that runs under the ArcView GIS software package. This system computes pesticide leaching risk ratings using the Revised Attenuation Factor (AFR) model (Li et. al. 1998). The AFR model is a process-based model that builds on the original attenuation factor (AF) model developed by Rao and others (1985). Both the AF and AFR models use a variety of soil and chemical properties to simulate the impact of these properties on pesticide leaching risk. The AFR model also incorporates the uncertainty in these soil and chemical properties in order to increase the accuracy of model predictions. Although the AF model was originally developed in Florida and adapted for use in Hawaii, the AFR model was developed specifically for use in Hawaii. The CLERS system is currently being used by the HDOA to estimate pesticide leaching risks before issuing application permits and other related licenses.

Evaluation results

As indicated above, Win-PST was evaluated and compared with the Hawaii-specific CLERS system on four sets of criteria: scope, consistency, accuracy and support.

Scope of the systems

Overall, Win-PST has a broader scope than CLERS both in terms of the input databases used and information outputs. The CLERS system provides more flexibility regarding chemical attributes while the Win-PST system allow for consideration of management practices as well as limited changes in soil properties. Table 1 contains a detailed comparison of the two systems.

Table 1 Scope of the systems

Attribute		Win-PST	CLERS
Databases used	Soils	All soils in NASIS database for the state	Sub-set of major agricultural soils, mainly on Maui and Oahu
	Chemicals	Over 450 chemicals	40 chemicals commonly used in HI
	Health effects	Human and fish health hazards	Not included
Outputs	Leaching Risk	Yes	Yes
	Solution runoff risk	Yes	No
	Adsorbed runoff risk	Yes	No
Other features	Adjustment for management	Yes	No
	Can the user input soil data?	Yes: surface layer depth, OM in surface layer, slope, macropores (Y/N)	No
	Can the user input chemical data?	No	Yes: Koc, T ½ , standard deviation of both variables

Consistency

The second criteria used to evaluate Win-PST was to determine whether Win-PST risk ratings were consistent with CLERS risk ratings. The rationale behind this criteria was that the CLERS system uses Hawaii-specific inputs including pesticide properties (Koc and T ½), incorporates uncertainty to some extent, and has been used successfully in Hawaii for several years. Therefore, CLERS results were assumed to more accurately reflect local conditions.

Leaching risk ratings were compared for 38 pesticides and 7 soil map units. The 38 pesticides used were those that were included in both systems. Since both models use soil map unit as the unit of analysis, the State Soil Scientist and State Resource Soil Scientist were consulted to identify soil map units commonly used for agriculture that represented a range of soil conditions. Because of limitations in the CLERS database, the comparison was confined to soils on the islands of Maui and Oahu. A complete list of the soil map units and chemicals used can be found in Appendix 1.

Because the systems produce different outputs, some recoding was necessary to facilitate comparison. The Win-PST system rates leaching risk on a five point scale: Very Low, Low, Intermediate, High, Extra High. In contrast, the CLERS system provides one of three ratings: Not Likely, Uncertain and Likely. In addition, an uncertain rating in the CLERS system can have at least two potential interpretations. It can be interpreted as Intermediate between Likely and Unlikely, or it can be interpreted as simply Unknown due to significant variation in one or more of the key chemical properties that influence leaching risk. As a consequence, three different comparisons were used. The variables used in the comparisons are summarized in Table 2.

Table 2 Variables used in system comparisons

Comparison	Win-PST variable	CLERS variable
Basic	"Very Low" and "Low" ratings combined	No changes
Win-Pest action level	"Very Low" and "Low" ratings combined; "Intermediate" and "High" ratings combined	No changes
Dual action level	"Very Low" and "Low" ratings combined; "Intermediate" and "High" ratings combined	"Uncertain" and "High" ratings combined

Basic comparison

The results of the basic comparison between the two models are shown in Table 3 and Figure 1. There is a significant ($\gamma = 0.854$, $p < 0.05$) positive correlation between the risk rankings. Overall, there is a higher level of agreement on high risk situations and a somewhat lower level on lower risk situations with CLERS showing a significant number of Uncertain ratings in situations where Win-PST indicates that the leaching risk is Low.

Win-PST action level comparison

The national NRCS Conservation Practice Standard 595 for Pest Management states that risk mediation is necessary if the Win-PST risk rating is Intermediate, High or Extra High. In this comparison, I reclassified the Win-PST ratings as either "Action required" (Intermediate or High) or "No action required" (Low or Very Low) and compared those to the CLERS ratings. Results of this comparison are shown in Table 4 and Figure 2. As above, there is a significant ($\gamma = 0.897$, $p < 0.05$) positive correlation between the two sets of leaching risk ratings. In this comparison, there is strong agreement between the systems regarding both high and low risk situations. The CLEARS "Uncertain" ratings are nearly evenly divided between Win-PST "Action required" and "No action required" ratings.

Dual action level

For the third and final system comparison, I took the same action level approach described in the previous section and applied it to the CLERS system ratings. Under this scenario, both systems produced either a rating of "Action required" or "No action required." As shown in Table 5 and Figure 3, this produces similar results to the two previous comparisons. Ratings remain significantly positively correlated ($\gamma = 0.924$, $p < 0.05$). This comparison represents the extreme "safety-first" approach to pesticide pollution risk management. Ratings from both systems would direct land managers to undertake mitigation a significant percentage of the time. CLERS provides a more risk averse rating than Win-PST. Based on CLERS ratings, some form of mitigation would be appropriate in 235 out of 266 situations (88%). Under Win-PST ratings, mitigation would be recommended significantly less often (in 175 of 266 situations or 66%).

Accuracy

The third area evaluation criteria was how accurately the two ratings systems predicted pesticide leaching as observed in the field. Unfortunately, due to the high costs (both personnel and time) and the logistics involved, there are few studies that have attempted to measure pesticide leaching in tropical soils under field or laboratory conditions. However two primary sets of data were available: drinking water well monitoring data from Oahu and a field study of pesticide movement conducted by Gavenda *et. al.* (1996). Additional data was obtained from Schneider *et. al.* (1990) related to the movement of one specific pesticide, fenamiphos.

USGS drinking water well monitoring

Two pesticides, atrazine and dieldrin, were found in Oahu drinking water wells during monitoring by the USGS under the National Water Quality Assessment (NAWQA) Program (data available at: http://wwwdhihnl.wr.usgs.gov/nawqa/gw_sus.html). Atrazine was found in 5 of the 29 wells monitored. Dieldrin was found in 2 wells. The Win-PST system rated atrazine at high risk for leaching on all 7 soils used. The CLERS system also rated atrazine as likely to leach on 6 of 7 soils and uncertain on the 7th (Pane series). The Win-PST system rates dieldrin at low risk of leaching due to its high propensity to be adsorbed on organic matter. It is not included in the CLERS pesticide database. Although Dieldrin is a very persistent pesticide (long half-life), its presence in groundwater is not well explained.

Gavenda et. al. (1996), *Schneider et. al.(1990)*

In a study published in 1996, Gavenda and others reported on field experiments conducted in four locations (three on Oahu, one on the Island of Hawaii) to measure downward movement and in situ degradation of five common agricultural pesticides: ametryn, atrazine, chlorpyrifos, fenamiphos and hexazinone. I was able to compare his results for three of the four soils used (the fourth was omitted due to classification questions discussed by the authors in the paper). Unfortunately, CLERS data was not available for the Hilo soil used in the study. Results from the Pane soil (an andisol from Maui) were used for comparison with the explicit recognition of significant differences between the two soils. Table 6 provides a summary of the results.

As indicated in the table, Gavenda and his colleagues found evidence of significant downward movement (high leaching potential) for atrazine and hexazinone, moderate downward movement (intermediate leaching potential) for ametryn, and very little movement (low leaching potential) for chlorpyrifos and fenamiphos. Behavior of the chemicals was similar across the soils used in the study. The Win-PST system provided risk assessments consistent with the field data for four of the five chemicals. In the case of fenamiphos, Win-PST produced a “high” risk rating, while field experiments showed little movement. The CLERS model only provided risk ratings for atrazine (two soils) and hexazinone (3 soils). These ratings were consistent with the field data. All other soil-chemical pairs were rated “Uncertain.” Using the dual action level method discussed in the previous section would lead a resource professional to recommend action inconsistent with field observations in the case of fenamiphos (both systems) and chlorpyrifos (CLERS only).

However, the higher leaching risk rating for fenamiphos is supported by the results of field sampling of soils under pineapple cultivation on Oahu and Lanai reported by Schneider *et. al.* (1990). They found movement of fenamiphos below the root zone and detectable levels at a depth of three meters suggesting that the leaching potential of fenamiphos may be greater than suggested by the Gavenda *et. al.* study.

Support

The final evaluation criteria used in this analysis was the availability of support for the risk assessment system. As an officially sanctioned and support NRCS technology, Win-PST has national support from the NRCS Water and Climate Center. The agency is committed to keeping the pesticide database up-to-date. Win-PST is configured to use soils data exported from the NASIS database. As a result, it should be relatively simple to update soils information as necessary.

The CLERS system is already being used locally and its use is supported by the HDOA. However, due to funding and personnel constraints, there is limited local support for either system expansion to include new chemicals and additional soil information or to revise existing databases to reflect new information. If NRCS were to adopt this system, agency funding would likely be necessary for system expansion and maintenance.

Recommendations

Based on the analysis reported above, I recommend the following:

1. NRCS-Hawaii should adopt Win-PST as the official pesticide risk assessment tool for use by field office personnel in writing pest management plans and include it in the State Conservation Practice Standard for Pest Management (#595).
2. NRCS-Hawaii personnel should continue to work with the Water and Climate Center (NRCS-WCC), with local scientists at the University of Hawaii, and with members of the Tropical Technology Consortium to evaluate the accuracy and appropriateness of the model under Hawaii and other tropical conditions including:
   - 2.1. Updating the Win-PST soils database as necessary to reflect new and revised soil properties (especially from the Island of Hawaii)
   - 2.2. Identifying possible adjustments in input parameters (e.g. increasing effective surface layer depth to account for deep organic matter in some Andisols).
   - 2.3. Assessing the impact of intense, concentrated rainfall events on pesticide leaching. Studies (e.g. Schneider et. al. 1990) suggest that major rainfall events may have a significant impact on leaching. This may be particularly important in Hawaii and other tropical areas where large amounts of rain can fall in short periods of time. This issue is currently not addressed by Win-PST.
   - 2.4. Identifying areas of concern or uncertainty ("knowledge gaps") that could be addressed by targeted laboratory or field studies and working with UH faculty, Tropical Technology Consortium members, and other interested parties to implement these studies.
3. NRCS-Hawaii should continue to work with NRCS offices in other tropical regions (Pacific Basin Area, Caribbean Basin Area, Florida) to insure that knowledge gained in Hawaii on the use of Win-PST in tropical soils is shared. The Tropical Technology Specialist in Hawaii and other Tropical Technology Consortium members can help facilitate this process.

References

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Table 3 Basic Comparison

		CLERS Leaching Risk Rating		
		Not Likely	Uncertain	Likely
Win-PST Leaching Risk Rating	High	0	26	92
	Intermediate	3	33	21
	Low / Very Low	28	56	7

Table 4 Win-PST Action Level Comparison

		CLERS Leaching Risk Rating		
		Not Likely	Uncertain	Likely
Win-PST Leaching Risk Rating	Action required	3	59	113
	No action required	28	56	7

Table 5 Dual Action Level Comparison

		CLERS Leaching Risk Rating	
		No action required	Action required
Win-PST Leaching Risk Rating	Action required	3	172
	No action required	28	63

Table 6 Comparison of system ratings with Gavenda et. al. data

Pesticide	**Soil Series**	**Leaching Risk Rating**		
		Gavenda et. al.	**Win-PST**	**CLERS**
Ametryn	Molokai Series	Intermediate	Intermediate	Uncertain
	Wahiawa Series	Intermediate	Intermediate	Uncertain
	Hilo Series	High	Intermediate	Uncertain
Atrazine	Molokai Series	High	High	Likely
	Wahiawa Series	High	High	Likely
	Hilo Series	Very High	High	Uncertain
Chlorpyrifos	Molokai Series	Low	Low	Uncertain
	Wahiawa Series	Low	Low	Uncertain
	Hilo Series	Low	Low	Uncertain
Fenamiphos	Molokai Series	Low	High	Uncertain
	Wahiawa Series	Low	High	Uncertain
	Hilo Series	Low	High	Uncertain
Hexazinone	Molokai Series	High	High	Likely
	Wahiawa Series	High	High	Likely
	Hilo Series	High	High	Likely

Figure 1 Basic Comparison

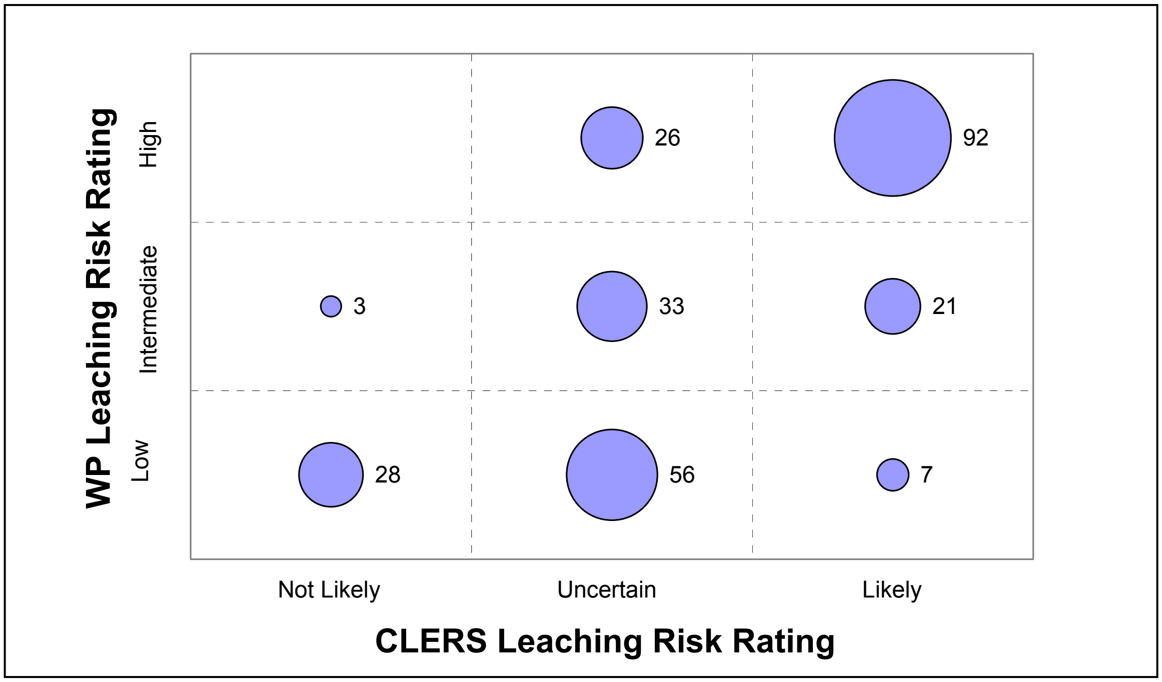


Figure 2: Win-PST action level comparison

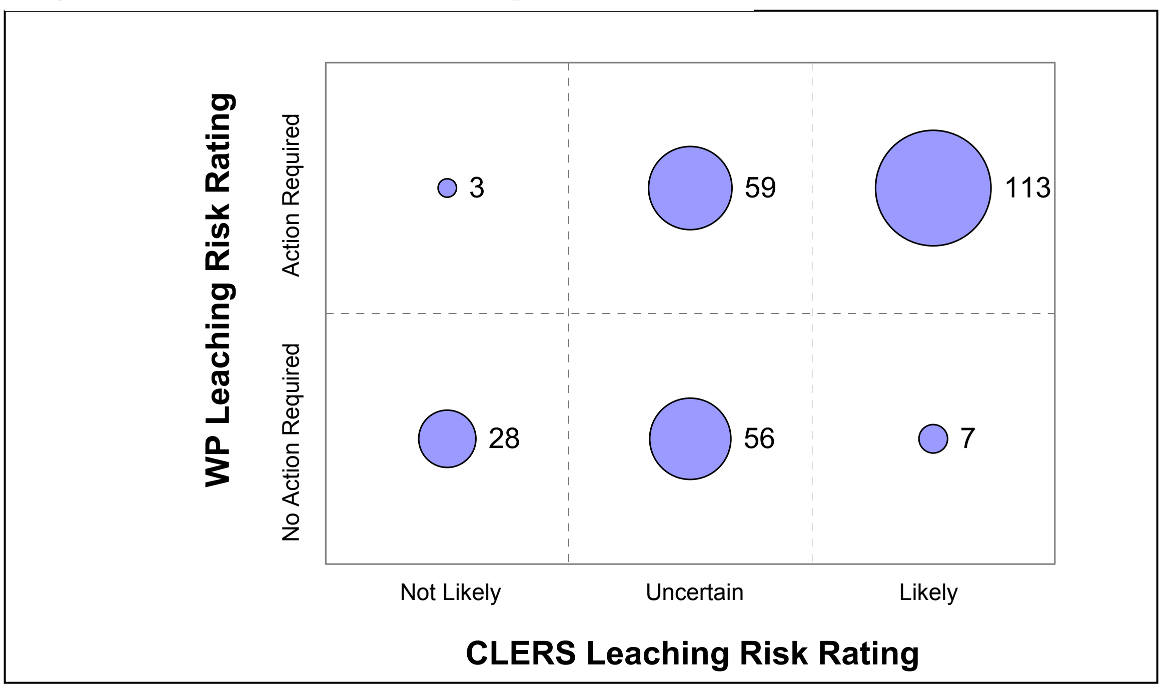
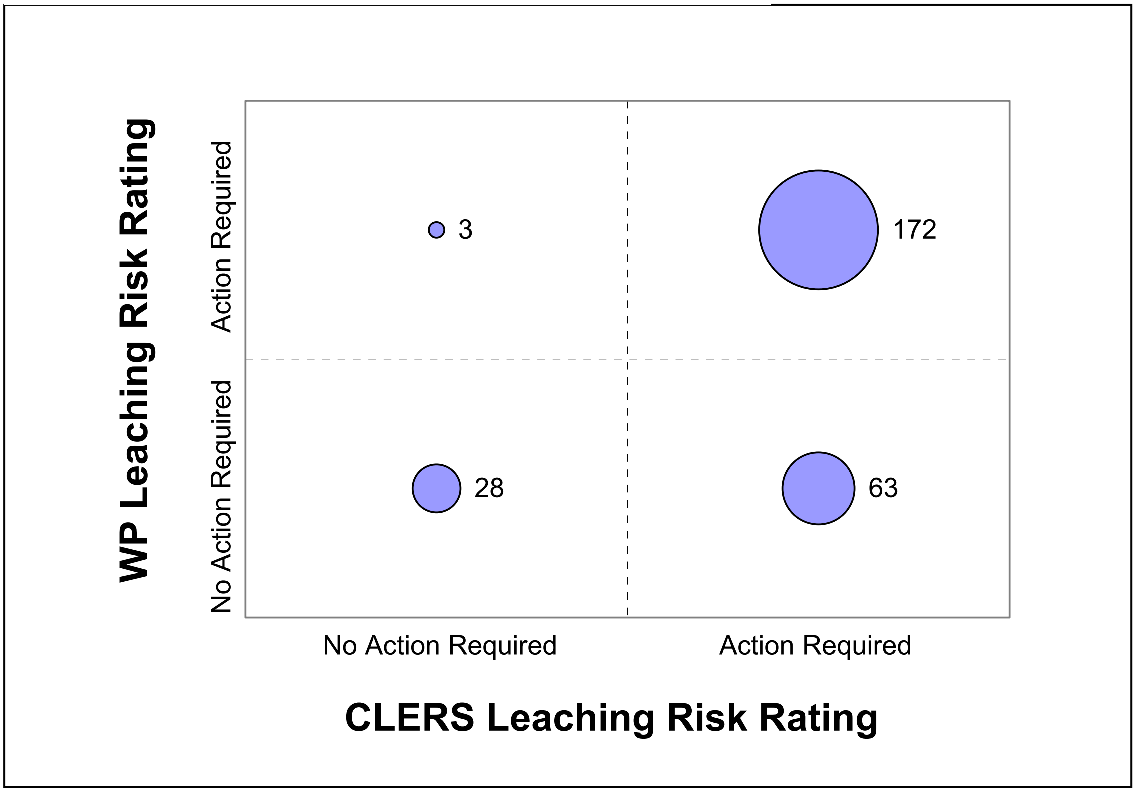


Figure 3 Dual action level comparison



Appendix 1: Soils and chemicals used in system comparisons

Soil Map Units

Keahua (KnB), Maui
Kolekole (KuB), Oahu
Lahaina (LaB), Maui
Molokai (MuA), Oahu
Pane (PXD), Maui
Wahiawa (WaA), Oahu
Waialua (WkA), Oahu

Chemicals

2,4,5 T
2,4 D
Aldicarb
Aldicarb sulfoxide
Ametryn
Anilazine
Atrazine
Bromacil
Captafol
Carbofuran
Chlordane
Chlorpyrifos
Cyanazine
Cryomazine
DBCP
Dicamba
Diuron
EDB
Endosulfan
Fenamiphos
Glyphosate
Heptachlor
Hexazinone
Lindane
Malathion
Methomyl
Methoxychlor
Methyl bromide
Metribuzin
Oxamyl
Paraquat
Prometon
Prometryn
Propazine
Simazine
Toxaphene
Trichlorfon
Triclopyr